INVESTIGATION OF THE GROUND WATER FLOW SYSTEM IN GEM VALLEY

by
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INTRODUCTION

Location of Gem Valley

Gem Valley is located 45 miles southeast of Pocatello along the divide between the Bear and Portneuf river basins. Portneuf Valley forms the northern boundary while the Bear River cuts through the southern end of Gem Valley (Figure 1). Mountain ranges form the east-west boundaries, with the Fish Creek Range to the east and the Soda Springs Hills and the Bear River Range to the west. The Bear River enters Gem Valley through a gap between the Soda Springs Hills to the north and the Bear River Range to the south. The river follows the valley edge southward before turning west, cutting the Black Canyon, then flows south through Gentile Valley. The valley floor slopes gently away from Soda Point at an elevation of 5700 feet above sea level towards the southwest to Turner with an elevation of 5500 feet and toward the northwest to Bancroft with an elevation of 5450 feet.

Scope of the Report

In response to inquiries from Gem Valley Water Users concerning possible declining ground water levels and well interference problems, a geohydrologic study was initiated by the Department. The specific objectives of the study were to: 1) determine if ground water levels were declining on a local or regional level; and 2) determine if well interference was affecting water user's ability to fill their water rights.

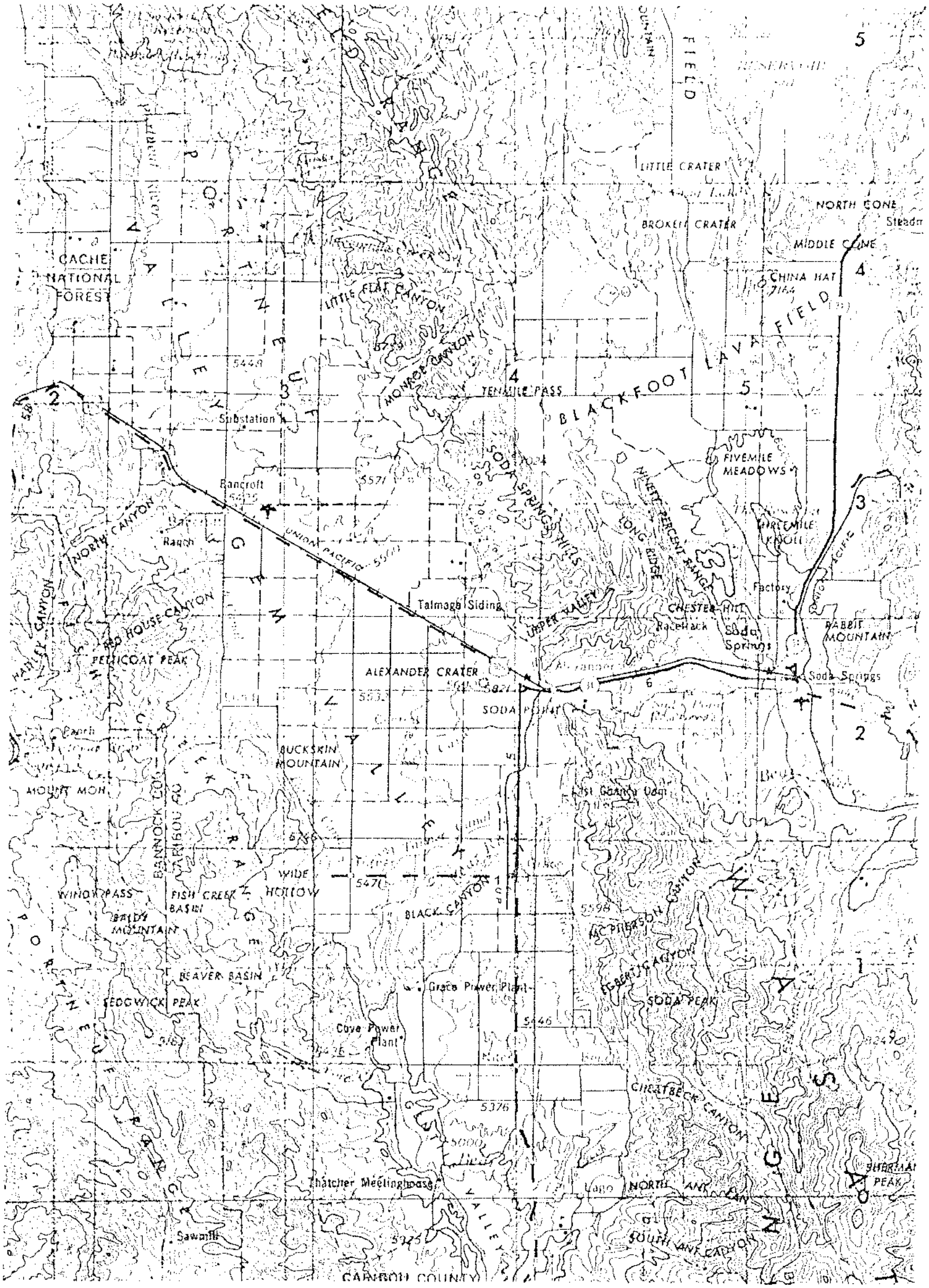


Figure 1. Location of Gem Valley, Portneuf Valley and Gentile Valley.

GEOHYDROLOGIC SETTING

Geology

The drainage system of ancestral Thatcher Basin was considerably different 34,000 years ago than it is today. Thatcher Basin included all of Portneuf Valley, Gem Valley, and Gentile Valley (Figure 2). Figures 3a-i illustrate the following discussion. Bear River and the drainage from Gem and Gentile Valleys flowed north, joining the Portneuf River, then leaving the Thatcher Basin through the Portneuf Gorge. Local basalt flows in the Portneuf Gorge dammed the surface drainage system approximately 33,500 years ago causing Lake Thatcher to form. The lake level rose and sediments from the rivers and streams were deposited in the backwaters behind the basalt dam. Over the next thousand years, basalts began filling the basin and eventually divided the lake in half. Lake levels continued to rise as no stream left the lake. Lake bed sediments and basalt flows continued to fill in the lake. Approximately 27,000 years ago, Lake Thatcher began to overflow at its southern shore, diverting the flow south into Lake Bonneville and initiated the downcutting that formed the Oneida Narrows. By 20,000 years ago, Lake Thatcher had drained and erosion began on the sediments that were deposited in the lake. Bear River began cutting its present channel through the basalts to form Black Canyon. Approximately 18,000 years ago, the level of Lake Bonneville had risen to a level that backed its waters into southern Gem Valley and all of Gentile Valley. Lake Bonneville overflowed its dam at Red Rock

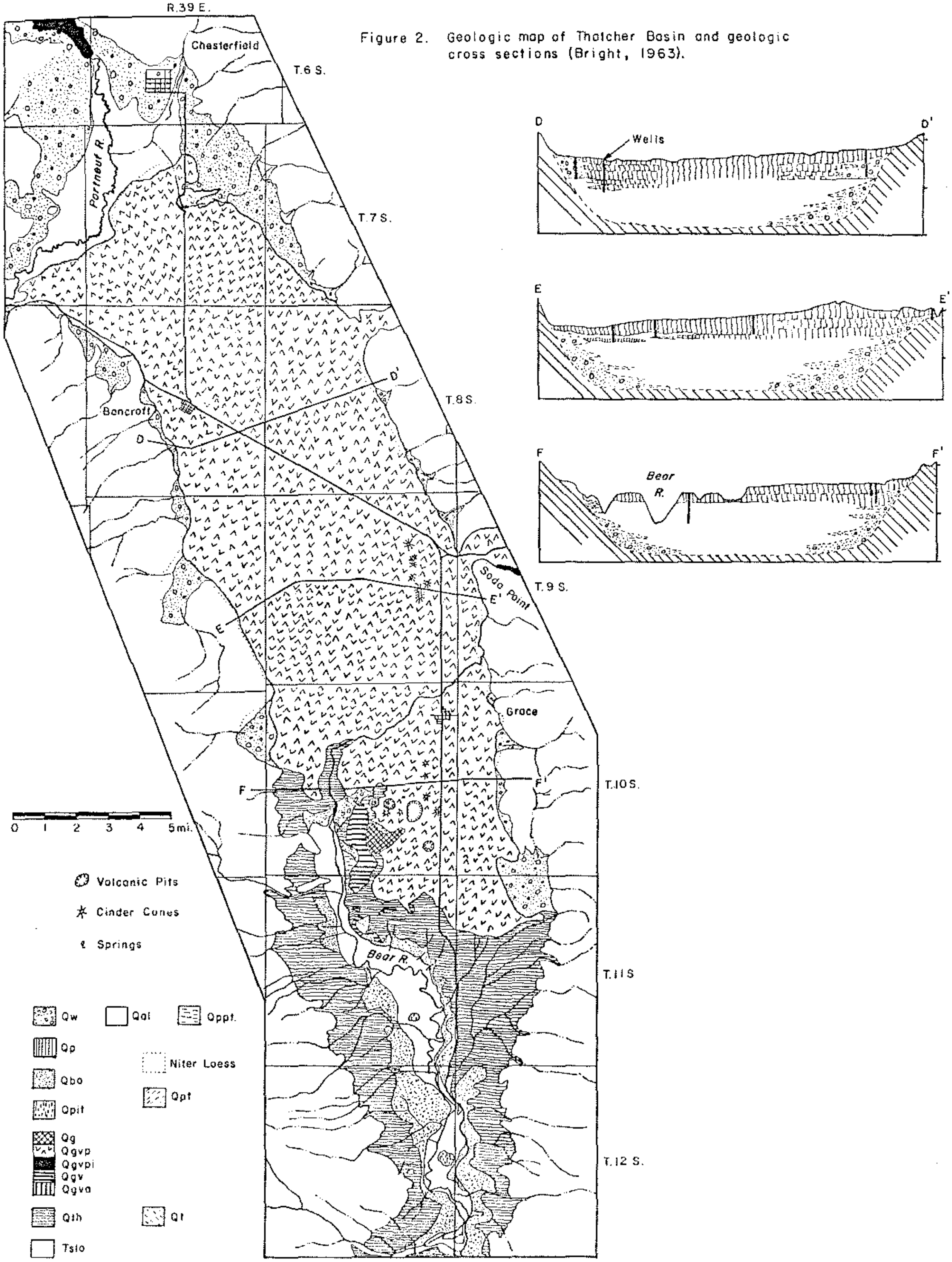
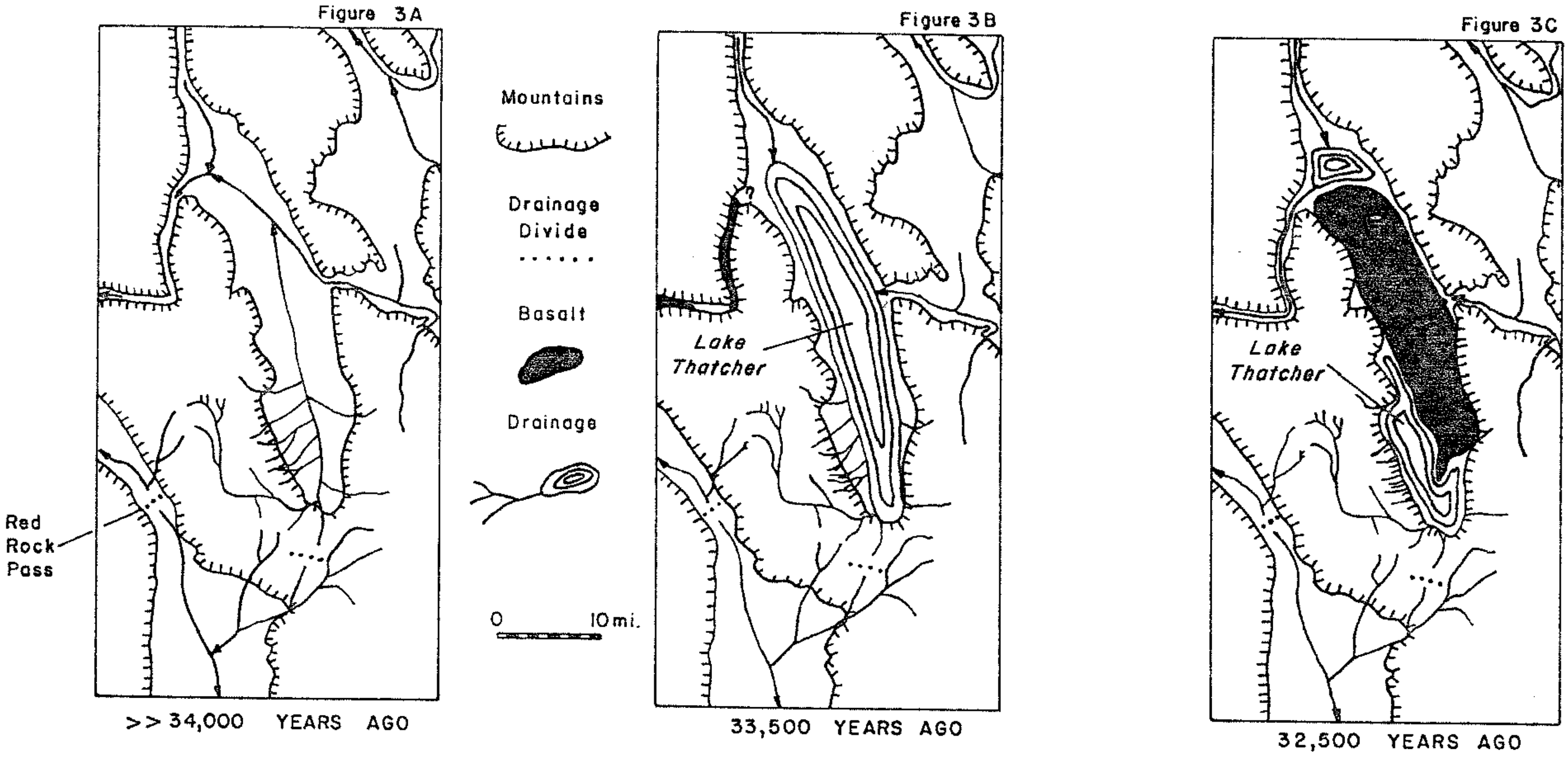
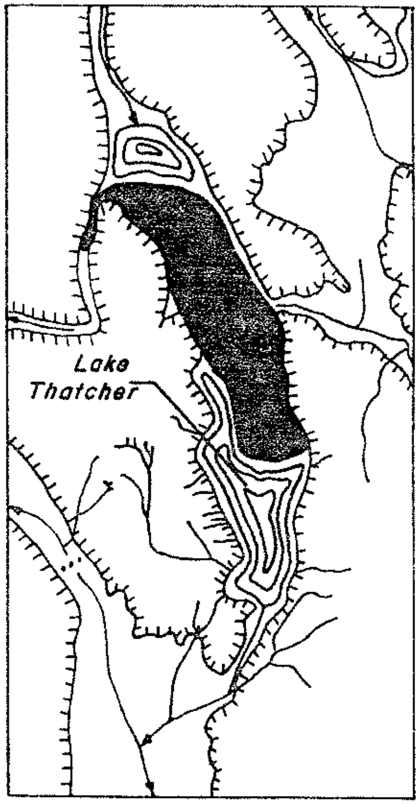


Figure 2. Geologic map of Thatcher Basin and geologic cross sections (Bright, 1963).



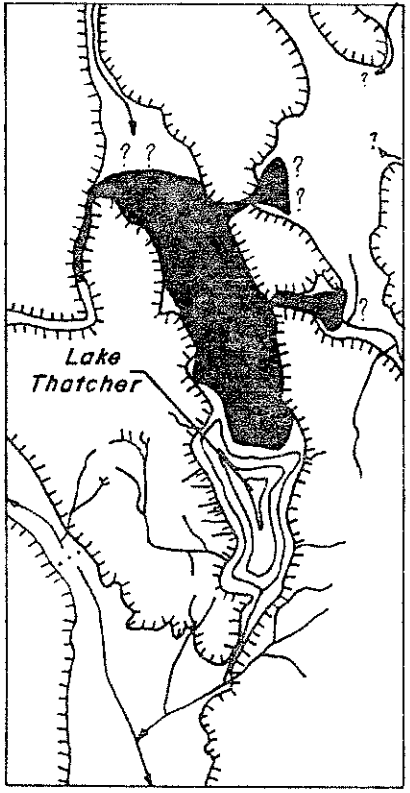
Figures 3A-3C. Development of Lake Thatcher and the present day drainage pattern (Bright, 1963).

Figure 3D



27,000 YEARS AGO

Figure 3E



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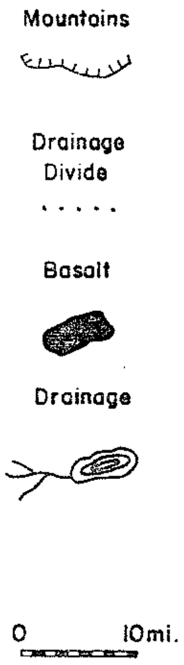
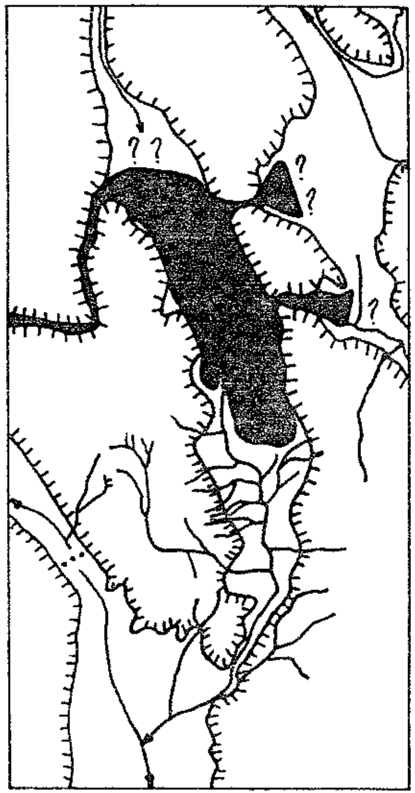
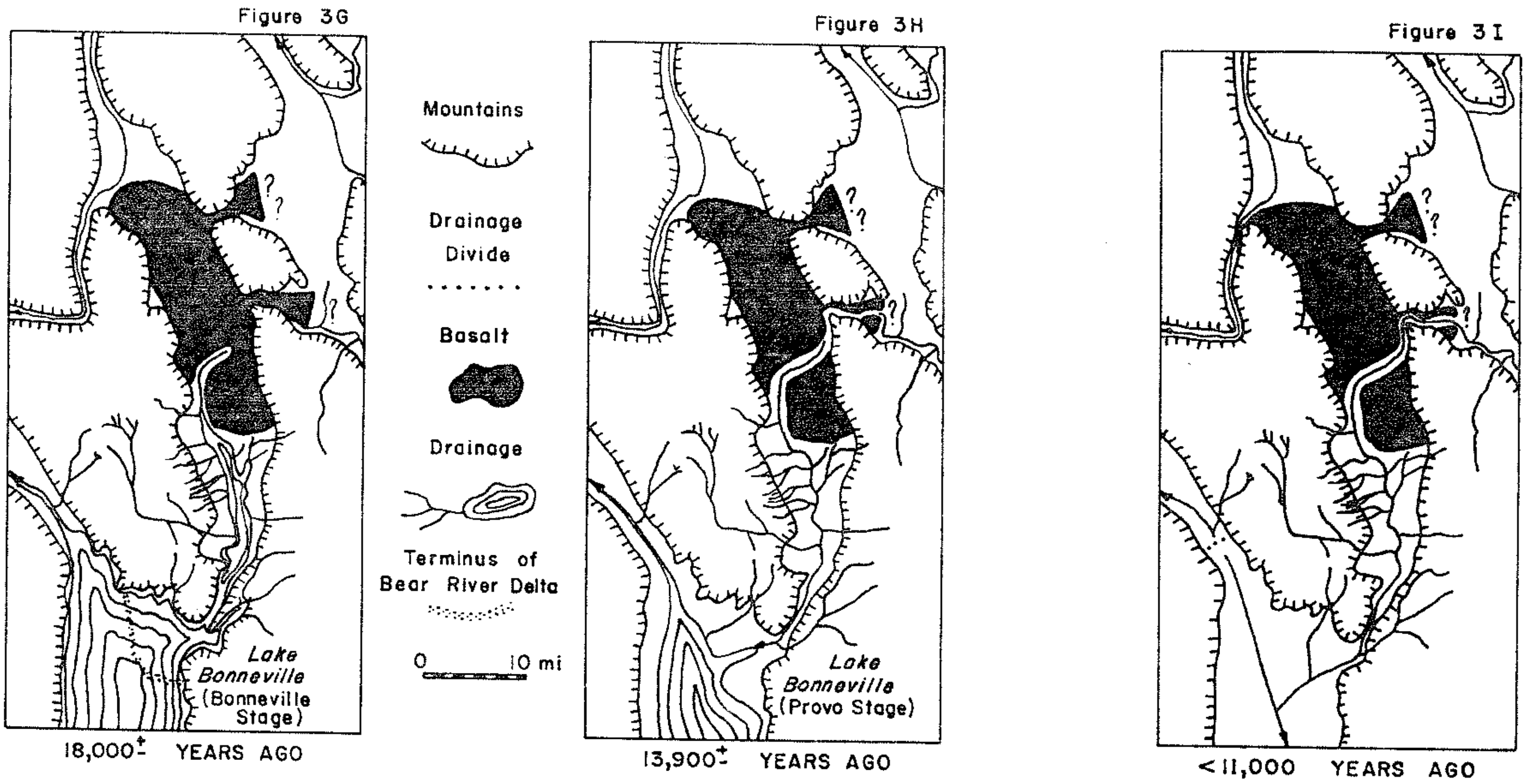


Figure 3F



20,000± YEARS AGO

Figures 3D-3F. Development of Lake Thatcher and the present day drainage patter (Bright, 1963).



Figures 3G-3I. Development of Lake Thatcher and the present day drainage pattern (Bright, 1963).

Pass and the water level began dropping rapidly till the channel reached bedrock (13,900 years ago). Lake Bonneville continued to drain at a slower rate. Inflow to the lake was less than outflow so the level continued to drop until it reached its present day size (Great Salt Lake). The surface features shown in Figure 3i are similar to present day conditions.

Geologic cross sections demonstrate the current geologic environment (Figure 2). The ground water flow system is greatly affected by the geologic events that formed the present day topography. The sediments that were deposited in Lake Thatcher underlie the basalts in most of Gem Valley. Gravel and sand beds are generally confined to the basin margins and the mouths of streams. As a stream leaves the mountains and enters the valley, the velocity of the stream generally decreases due to a change in the gradient of the surface that the stream flows over. As the stream's velocity decreases the ability of the stream to carry sediment also decreases. Therefore, the coarser, heavier, sediments are deposited first. The sediments grade finer towards the center of the valley with silt and clay beds interfingering with the near shore sands and gravels.

The Gem Volcanics are dark to very dark gray porphyritic olivine basalts. Porphyritic is a textural term describing igneous rock with large crystals, in this case - made of olivine, set in a finer mass. The basalt is fine-to-medium grained, slightly vesicular overall, and very vesicular at the top of the flow units. Vesicular basalts have small cavities that formed by the explosion of a bubble of gas or steam during the solidification of the basalt. The major source of the basalts were the cones and fissures near Alexander and between Niter and the Grace power-plant. A second source for the basalts was the Blackfoot Lava Field. These basalts flowed through Ten Mile Pass and past Soda Point.

Recent geophysical work in Gem Valley may have located a buried river channel along the western side of the valley (Mabey, 1971). Lake Thatcher may have overflowed the basalt dam at the Portneuf Gap allowing a channel to form. If the buried channel exists, it may be the reason for wells penetrating more sediments along the western edge of the valley than wells further to the east. Wells completed in these sediments need to be constructed in such a way as to limit sand from entering the well.

Due to the complex geology of the interface between the lake bed sediments and the basalts, it would be difficult to identify any given well depth at which point, deepening would no longer provide an increase in well yield. Most of the wells drilled for irrigation purposes are 200-300 feet deep; only a few are deeper than 400 feet. The following wells were completed below 500 feet:

	Location	Depth of Well	Depth to Water
1.	T.8S.-R.39E.-Sec. 16	575 feet	90 feet
2.	T.9S.-R.39E.-Sec. 8	585 feet	109 feet
3.	T.9S.-R.40E.-Sec. 20	525 feet	140 feet

Wells #1 and #2 completely penetrated the lake bed sediments with no basalt flows before entering the sandstones, limestone, or shales of the Salt Lake formation or pre-Tertiary formations (shales). Well yields from the Salt Lake Formation range from 0 to 1800 gallons per minute in the Bear River Valley. Well #3 did not fully penetrate the lake bed sediments, but did penetrate several basalt flows. No well yield information was reported for any of the three wells. Generally, the deeper the well, the lower the water level, but not in all cases. Continued drilling with aquifer tests would determine if deeper wells would be of benefit.

Mapping of the lake bed sediment-basalt interface could only be accomplished on a coarse scale because of the limited data available. Because of the complex nature of interface, this would be of little value in planning well locations and depths. More care should be taken in well design and construction the closer the well site is to the valley margin. Also, the more sediment encountered, the more critical the well design and construction.

Hydrology

The ground water flow system in Gem Valley is an unconfined aquifer except where saturated porous basalts are encountered beneath clay layers of the lake bed deposits which causes artesian pressure (confined aquifer). Wells may intercept one large producing zone or several small producing zones depending on the geology penetrated at that particular site.

Recharge to aquifer(s) occurs from precipitation both on the valley floors and as surface runoff from the mountains as there is very little surface drainage over much of the valley. Recharge probably also occurs as ground water flows through Ten

Mile Pass and through the gap at Soda Point. Seepage from irrigation canals and infiltration of excess irrigation water, both surface and sprinkler applied, also recharges the aquifer.

Discharge from the ground water flow system occurs as: 1) evapotranspiration where the potentiometric surface is near land surface; 2) discharge from springs into the Bear and Portneuf Rivers; 3) ground water flow through the Portneuf Gap; and, 4) through irrigation, domestic, and municipal pumpage. Evapotranspiration takes place near the springs and in the areas near the rivers and streams. Several springs occur on both sides of Black Canyon.

The direction of ground water flow in Gem Valley is unique because a ground water divide separates the valley into two flow systems (Figure 4). The ground water divide is not well defined towards Soda Point but is better defined towards Buckskin Mountain. The location of the divide is not stationary as changes in the flow pattern will develop in response to changes in pumpage or recharge, thus affecting the shape and position of the divide: the ground water north of the divide flows northwest discharging into the Portneuf River or as ground water under flow through the Portneuf Gap. South of the divide, the ground water flows south-southwest, discharging into the Bear River as springs in Black Canyon. Southeast of the Bear River, the ground water flow system is approximately 75 feet lower in elevation and the direction of flow is west towards the Bear River, also discharging from several springs.

As of November 1980, there were six observation wells in the

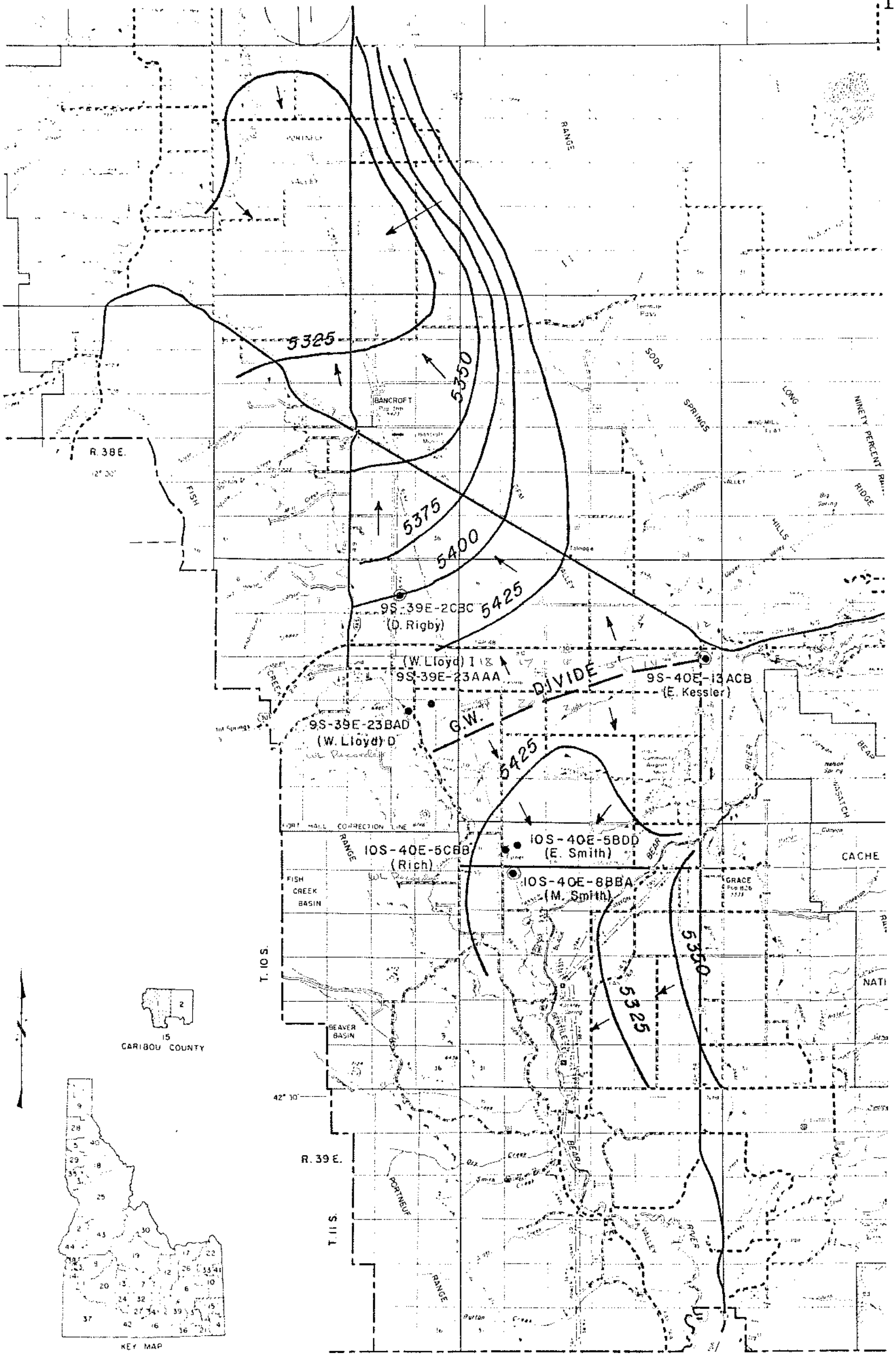


Figure 4. Ground water contour map showing the location of the divide and the direction of flow.

Portneuf, Gem and Gentile Valleys monitored by the Geological Survey. Five more wells were monitored by the Department between July and December 1980. Continuous water level recorders were installed on three of the wells. Figure 5 shows the location of the observation wells.

Water level recorders designed to operate while a pump is operating were installed in Everett Smith's irrigation well (T10S-R40E-Sec. 5BDD) and in Marvin Smith's irrigation well (T10S-R40E-Sec. 8BBA). The water level in the Everett Smith well dropped 56 feet from June 16 to June 30, 1980. Due to recorder problems, measurements were discontinued until October 15, 1980 when the water level was four feet above the June pre-pumping level (Figure 6). The water level rose almost two feet during October and November, then began a slow decline through December and January.

The Marvin Smith irrigation well, T10S-R40E-Sec. 8BBA, had a drawdown of 62 feet, but within two days after the pump was shut off, the water level was only two feet lower than pre-pumping levels and was higher than pre-pumping levels within two weeks (Figure 6). The hydrograph shows the water level recovered very rapidly when the pump was shut off. The water level fluctuated very little during the winter months.

The Russell Rich well, T10S-R40E-Sec. 5CBB, is an unused domestic well drilled in June 1980. The well is located approximately 1500 feet west of the E. Smith well and 2700 feet northwest of the the M. Smith well. Monitoring of the water level in the Rich well began the same day that both the M. Smith and E. Smith wells began

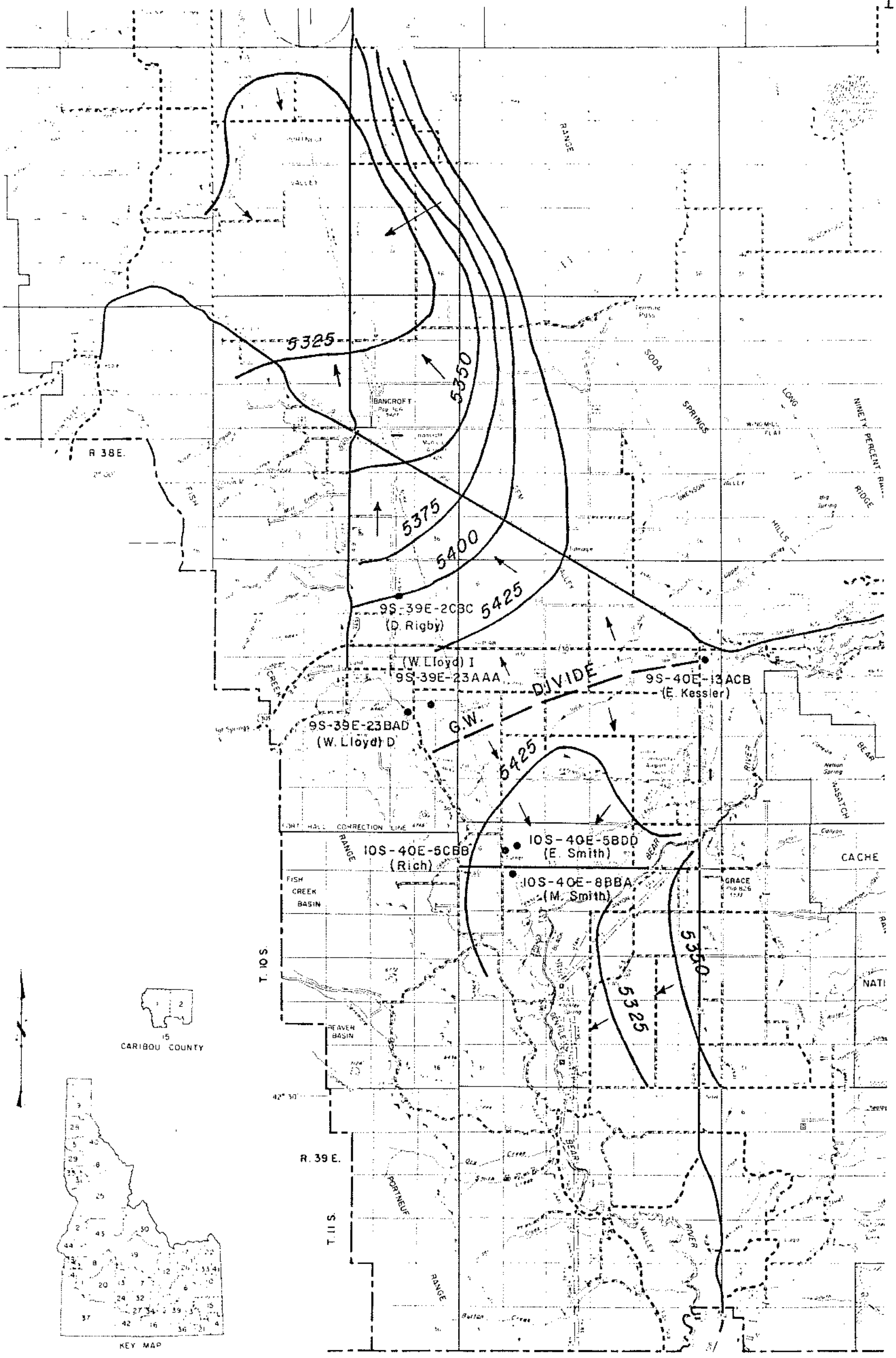
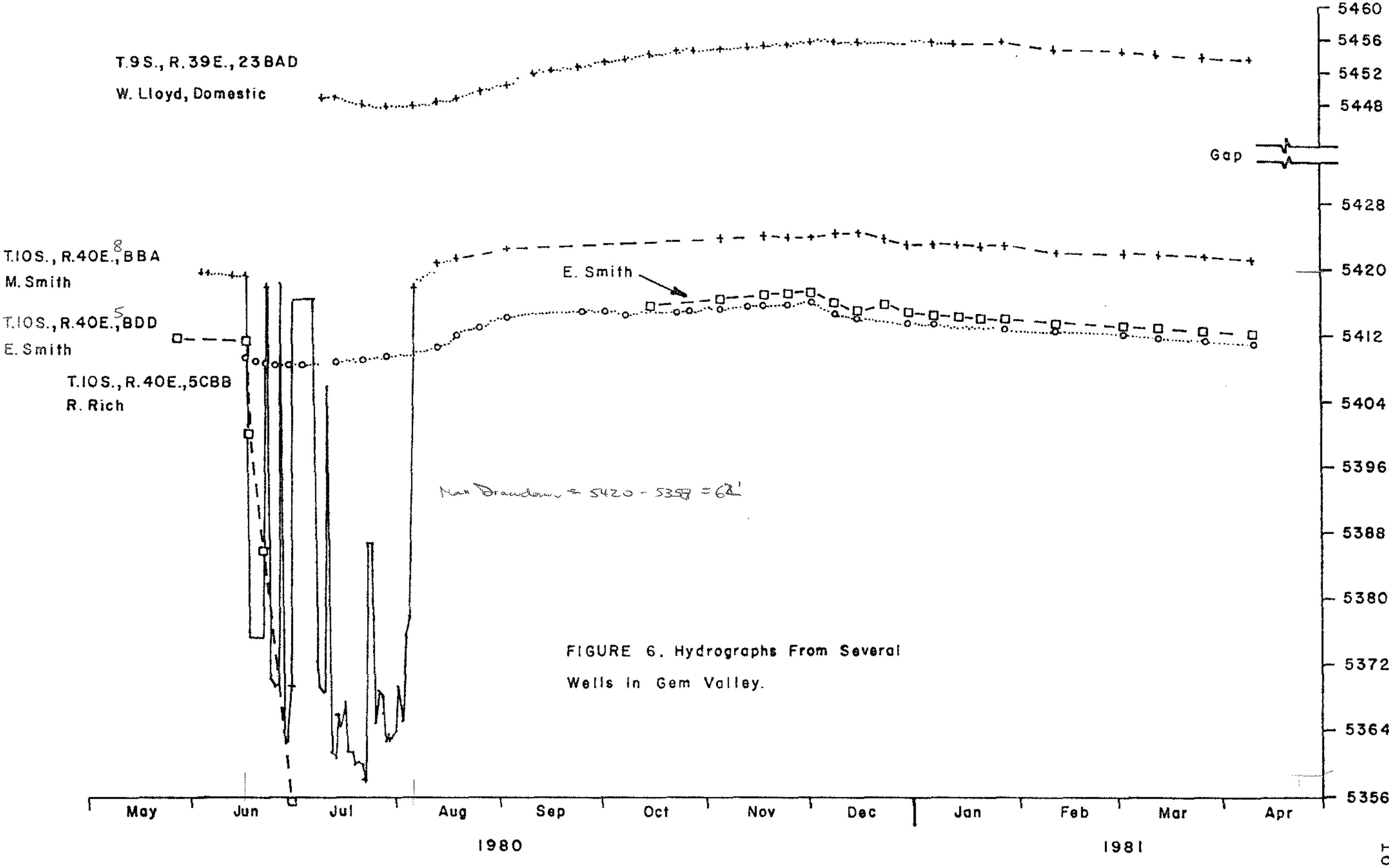


Figure 5. Location of observation wells.



Max Drawdown = 5420 - 5358 = 62'

FIGURE 6. Hydrographs From Several Wells in Gem Valley.

pumping in June 1980. The water level only dropped one foot over a four week period in late June and early July. The water level rose one foot in July, 4.5 feet in August, and approximately one foot in September. The water level began fluctuating in early October with an overall rise of one foot through October-November (Figures 6 & 7). The water level declined 2.7 feet during December and January.

Both an unused domestic well (T9S-R39E-Sec. 23BAD) and an irrigation well (T9S-R39E-Sec. 23AAA) of Warren Lloyd's were monitored. Spot measurements of the irrigation well were made during the summer while a water level recorder was installed on the domestic well in early July. The water level in the domestic well declined approximately one foot over three weeks then began rising slowly for the next four months (Figures 6 & 8). The water level declined approximately 0.5 feet from December to January. As no well log exists for the Lloyd domestic well, well construction and geologic data are not available. The well is located approximately 3000 feet west of the irrigation well. Seepage from the West Branch Canal, located approximately 1000 feet west of the domestic well, probably recharges the ground water system which is indicated by the rise in the ground water level of the domestic well.

?, Notes acquired from a well log, are in file, JB

Long term water level records in Gem Valley go back to 1967 and show only seasonal fluctuations. Ground water levels rise during the spring runoff and the summer irrigation season and decline during the winter months. No long term declines are indicated (Figure 9).

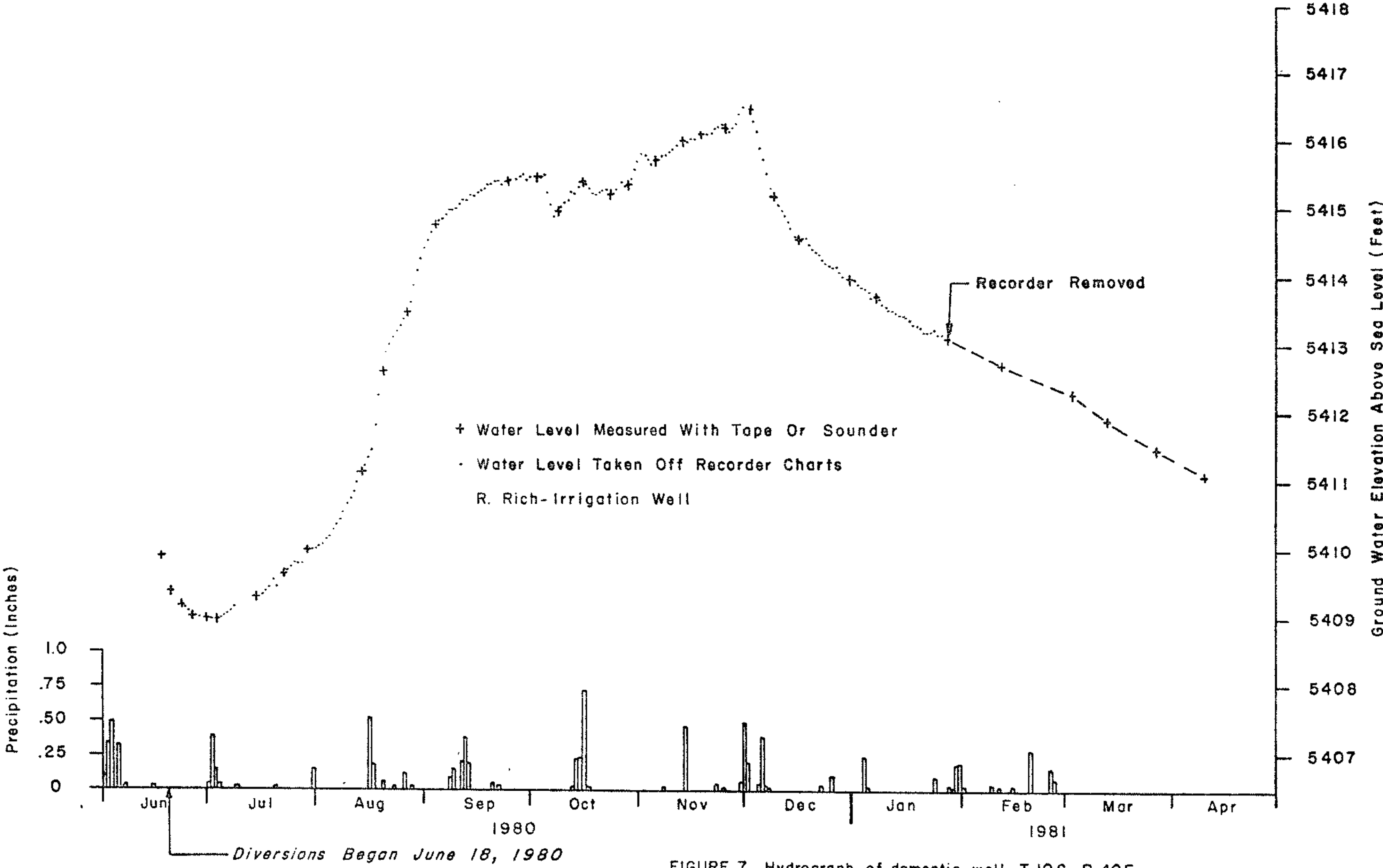
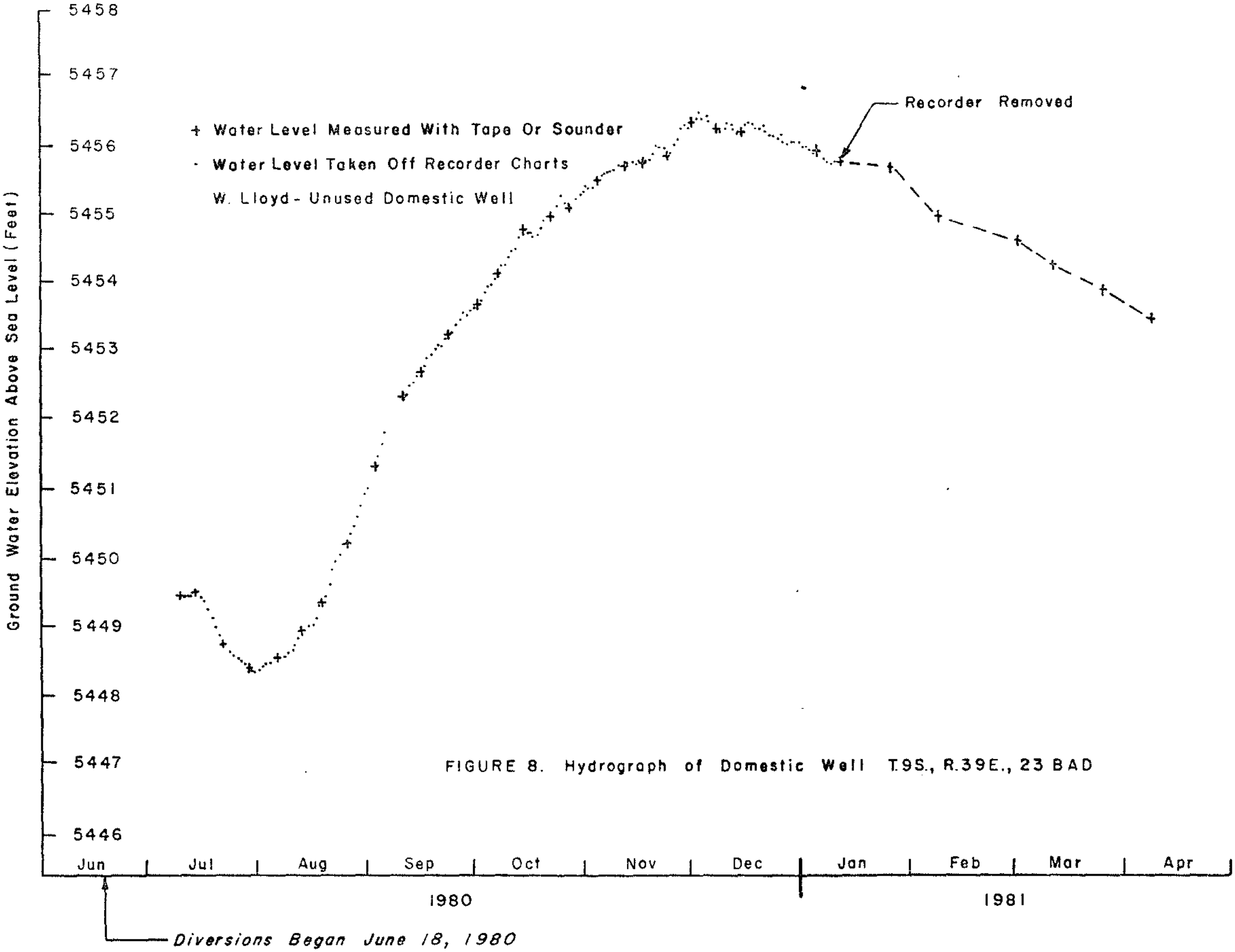


FIGURE 7. Hydrograph of domestic well T.10S., R.40E. 5CBB and Precipitation Data from Grace, Idaho.



Recorder Removed

Diversions Began June 18, 1980

FIGURE 8. Hydrograph of Domestic Well T.9S., R.39E., 23 BAD

OBSERVATION WELL HYDROGRAPHS, GEM VALLEY, IDAHO

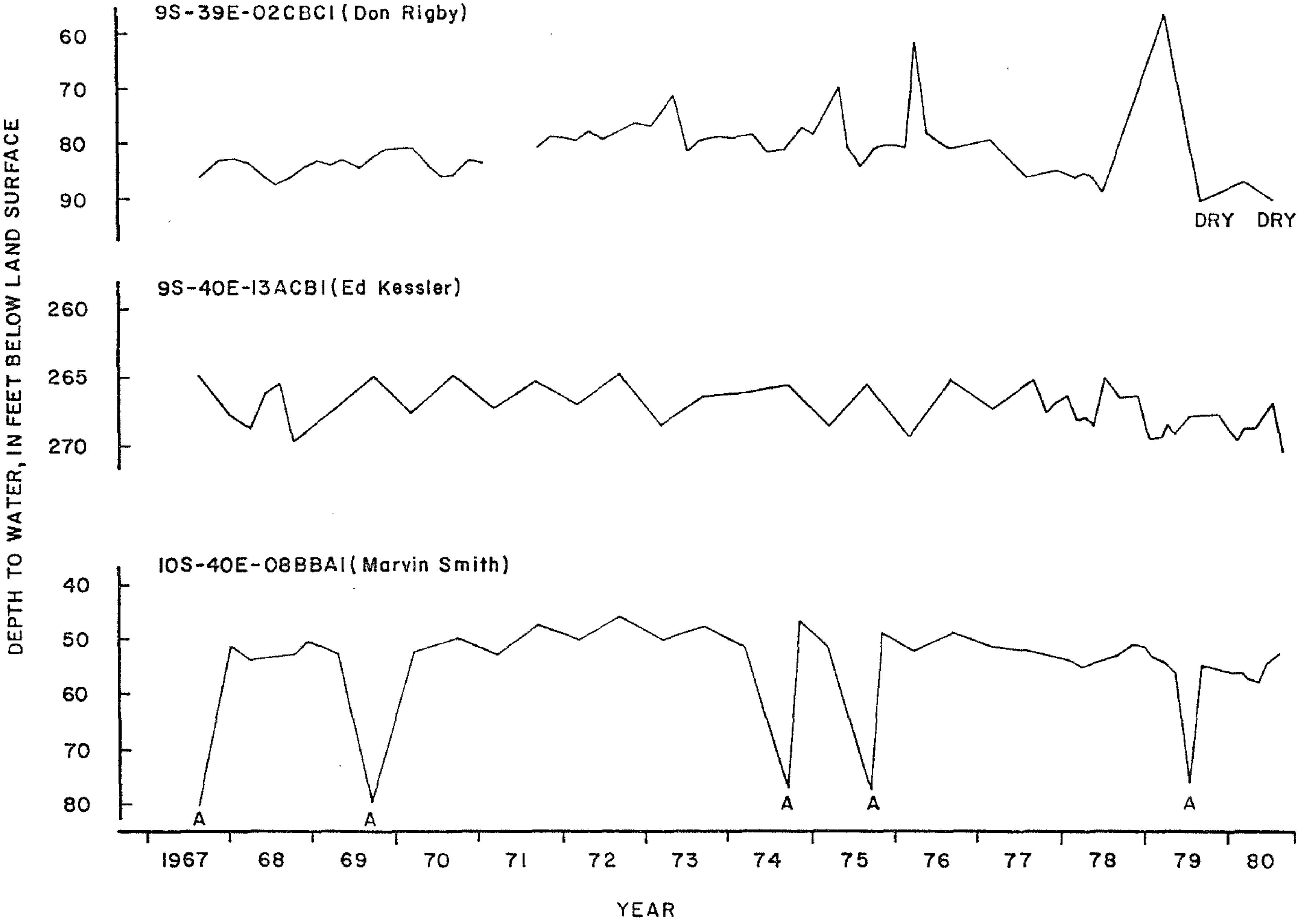


Figure 9. Hydrographs showing long term ground water level fluctuations.

Quantification of the effects of pumping in Gem Valley on the springs in Black Canyon or on the ground water flow into the Portneuf River System are beyond the scope of this study. The natural ground water flow system, composed of recharge, lateral flow, and discharge, has been affected by irrigation development. Surface water irrigation added a new source of recharge to the ground water flow system. The distribution system has changed over the years as well as the timing of the discharges. Areas formerly irrigated by surface methods have largely been converted to more efficient sprinkler systems and the saved water applied to additional lands. The more efficient use of surface water reduces recharge to the ground water system and the increasing use of ground water for irrigation will change the natural discharge from the system.

A noticeable reduction in flow of some of the springs on the south side of Black Canyon resulted from the replacement of the leaky wood stave pipeline which carried water to the Grace power-plant. Utah Power and Light Company has, in recent years, found it necessary to pass water down Black Canyon at times in order for Gentile Valley Canal to obtain an adequate supply because of an apparent decrease in flow of the springs (Jay Haight, Personal Communication). Because this decrease is the result of several factors, it would be extremely difficult to segregate the effect caused by irrigation pumping.

WELL DESIGN AND ITS EFFECT ON PUMPING LEVELS

? = $\frac{Q}{s}$

The specific capacity (Q/s) of a well is determined by dividing the rate of discharge from the well (Q) by the drawdown of the water level (s) within the well. Well construction, development, and the amount and location of perforations affects the relationship between discharge (Q) and drawdown (s). The ratio between discharge and drawdown (Q/s) decreases with increasing discharge when well losses are high. Well loss is drawdown due to turbulent flow of water through the perforations in the casing. Turbulent flow can be reduced by lowering the discharge from the well until the velocity of the water passing through the perforations is between 0.1 to 0.25 feet per second. A second method would be to increase the amount of open area in the casing. The open area of a casing is the area of open space per lineal foot.

Listed in Table 1 are specific capacities of several wells in Gem and Portneuf valleys. The specific capacity of wells penetrating mostly basalts ranges from 270 to 2625 gpm/ft of drawdown while wells that penetrate both sediments and basalts have specific capacities that range from approximately 2 to 31.3 gpm/ft of drawdown. It should also be mentioned that for wells completed in unconfined aquifers, the specific capacity decreases with increased drawdown.

Well construction plays a greater role in the productivity of wells completed in unconsolidated sediments than in basalts. The location, size, and amount of perforations must be large

TABLE 1. Specific Capacity* of Several Wells in Gem and Portneuf Valleys
(Norvitch & Larson, 1970)

Well Location		Depth (Feet)	Discharge (GPM)	Drawdown (Feet)	Specific = Capacity*	Static Water Level (Feet)	Geology of Aquifer Qb =basalt Qal=alluvium, Tsl=lake deposits
8S-39E	1dad	207	1600	3.	533.	192.64	Qb
	4cdc	235	200	excessive drawdown 100.	2	75.43	Qb, Tsl?
	5acb	260	495	183.	2.7	48.2	Qb, Qal?, Tsl?
	8bdd	293	1000	50.	20.	-------	Qb, Qal?, Tsl?
	10ada	345	1575	0.6	2625.	197.5	Qb
	15cba	173	1350	5.	270.	110.1	Qb
8S-39E	22bac	185	300	0.2	1500.	84.68	Qb
	27acb	355	300	45.	6.7	107.97	Qb, Qal?, Tsl?
	34add	170	1850	1.	1850.	83.39	Qb
8S-40E	16dcd	247	610	150.	4.1	63.80	Qb, Qal?, Tsl?
	21daa	175	2288	73.	31.3	71.66	Qb, Qal?, Tsl?
9S-39E	2dbb	132	1350	negligible drawdown 1.1	1227.	-----	Qb
10S-40E	5BDD**	208	1400	56.4	24.8	88.6	Qb, Qal?, Tsl?

* Discharge in gallons per minute divided by drawdown in feet.
** Data collected by IDWR personnel on E. Smith well (June 1980).

enough to allow the desired discharge to enter the well within the velocity requirements while preventing silt and sand from entering the well. Alternative well designs could include: 1) well screen alone; 2) gravel packing with well screen; or, 3) gravel packing with an increase in perforations per foot of casing. There are several kinds of screens on the market including the wire wrapped screen, the wedge shaped wire wrap screen, the shutter screen, and the gravel guard screen. The latter two screens have a vertical or horizontal louver designed slot pattern. Any of these screens have a greater open area per foot than a slotted casing (up to 10 times as much open area per lineal foot [Johnson Division]).

Hypothetically, compare the design of four wells: 1) wells "A" and "B" are 164 feet deep and are located in the same water table aquifer (Figure 10); and, 2) wells "C" and "D" are 330 feet deep and penetrate two producing zones (Figure 11). Wells A and C were constructed similar to irrigation wells in Gem Valley while wells B and D demonstrate an alternative well design; well screen. Well screen with the same diameter as the slotted casing would allow the same amount of water to enter the well, but at a lower entrance velocity and when properly sized, prevent sand from entering the well. When the entrance velocity is maintained below 0.1 ft. per second, friction losses will be negligible and the rates of incrustation and corrosion will be minimum (Johnson Division). Wells A, B, C, and D are only examples of possible well designs. Each well should be constructed to meet the specific geologic conditions encountered and the desired well yield.

Figure 10. Well designs for a shallow well.

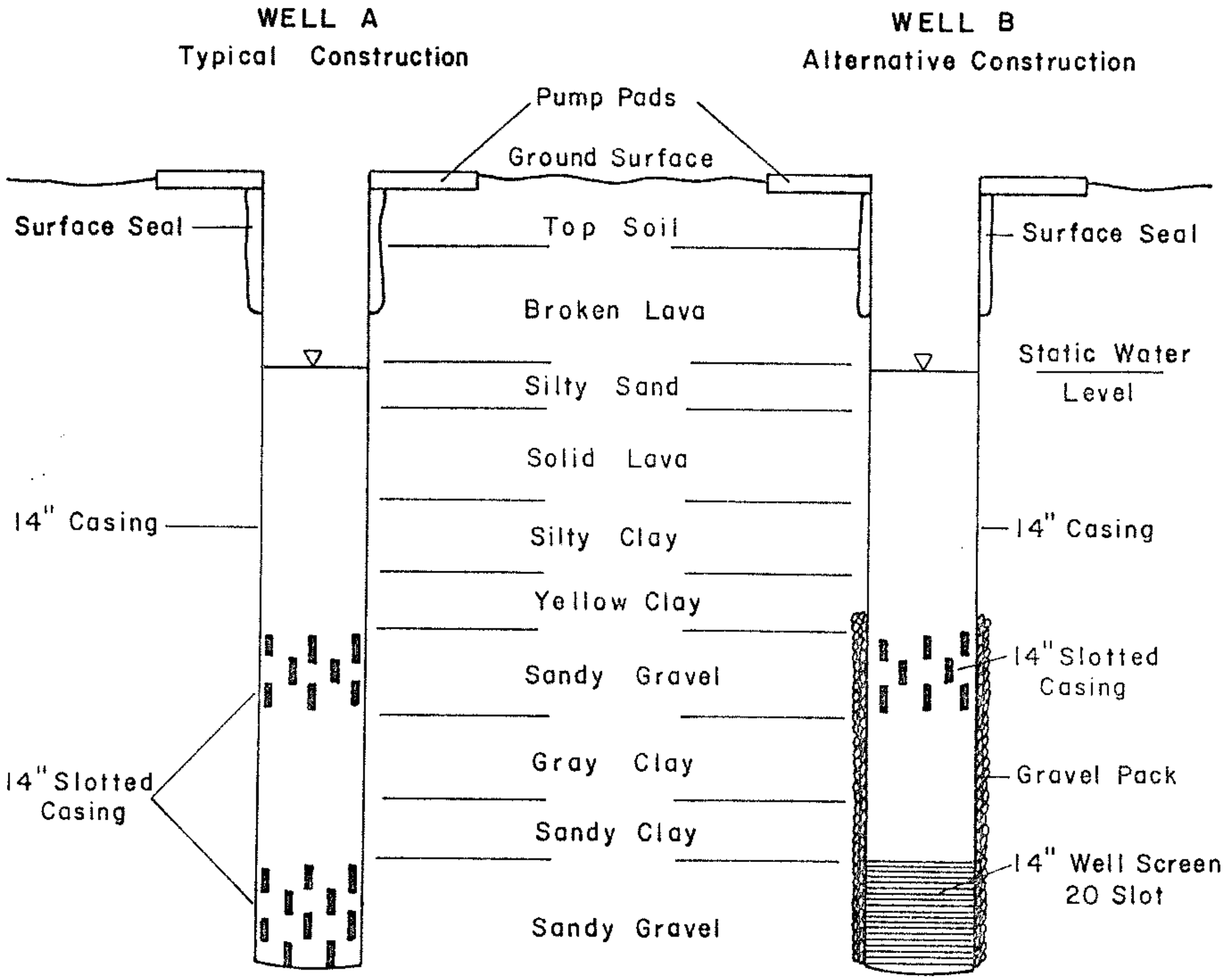
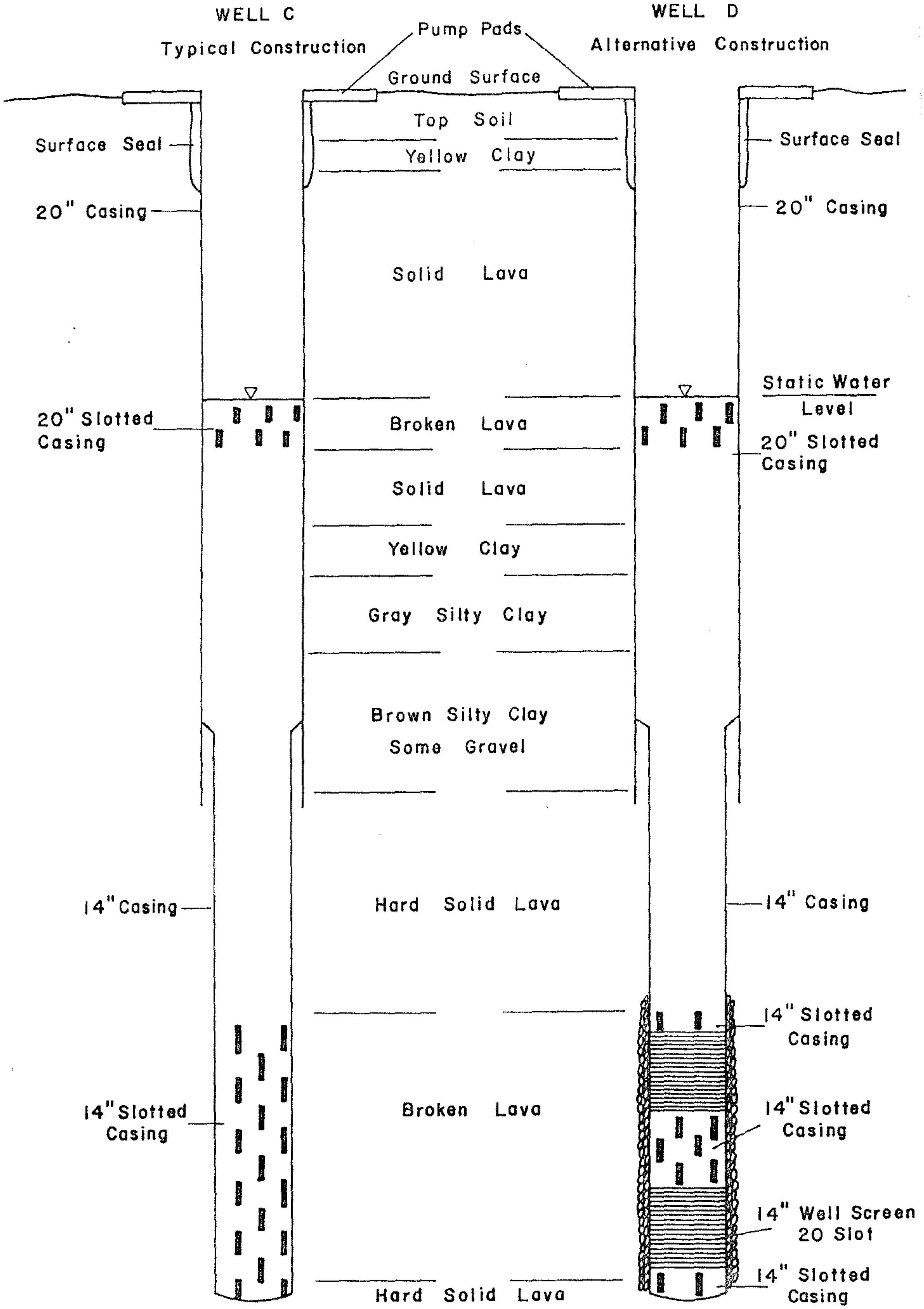


Figure 11. Well designs for a shallow well.



Conclusions

1. Wells penetrating the basalt aquifers in Gem Valley are good to excellent producers (1350 GPM with 5 ft. of drawdown) while wells completed in the lake bed sediments and basalts interfingered are poor to good producers (610 GPM with 150 ft. of drawdown).
2. USGS observation wells in Gem Valley do not indicate any long term decline of ground water levels.
3. An irrigation well, T10S-R40E-Sec. 8BB$\overset{A}{\text{B}}$, recovered rapidly from pumping for the 1980 irrigation season.
4. Two unused domestic wells showed very little response to nearby irrigation pumping.
5. Wells that encounter heaving sand zones in the lake bed sediments could show a decrease in the well yield and/or excessive wear on the pump bowls if the well construction does not prevent the movement of sand into the well.
6. Ground water fluctuations do not indicate that the cones of depression caused by production pumping are of great areal extent, therefore, well interference does not play a significant role in well yield problems at this time.
7. Pumping levels in Gem Valley are a result of aquifer characteristics and well construction, not major well interference or large scale depletion of the ground water resource.

Recommendations

1. Wells penetrating the lake bed sediments that are experiencing yield problems should either be pumped at a lower rate so that the pump does not "suck air" or be deepened, either encountering more production zones or providing storage and the ability to pump from a lower depth.
2. New wells or reconstructed wells to be completed in sand zones should consider alternatives to slotted casing: 1) well screen, 2) well screen and gravel packing, or 3) gravel packing with slotted casing.

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